Optimal drinking water softening by the use of water quality indicators

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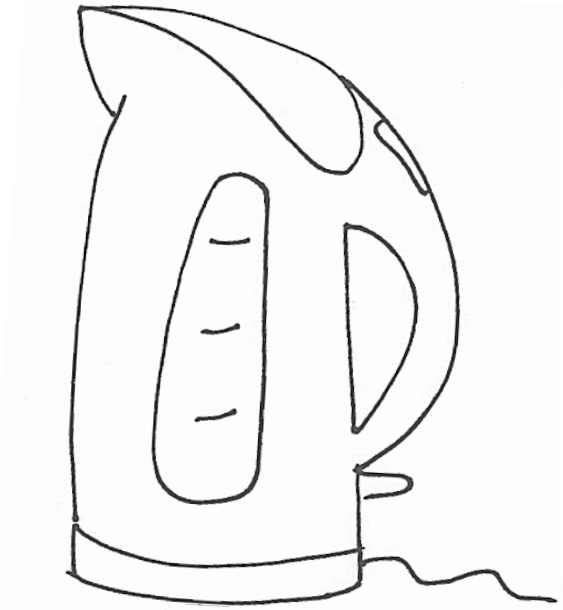
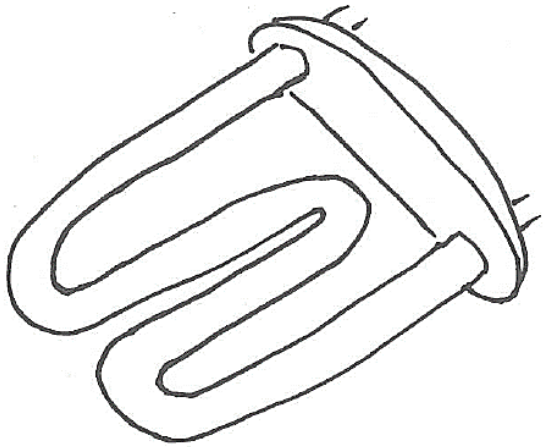
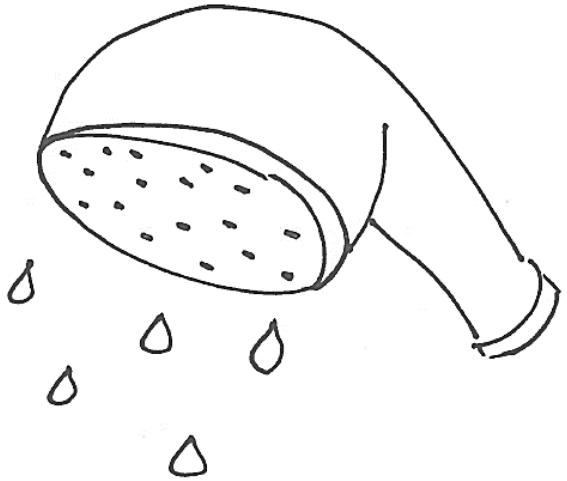
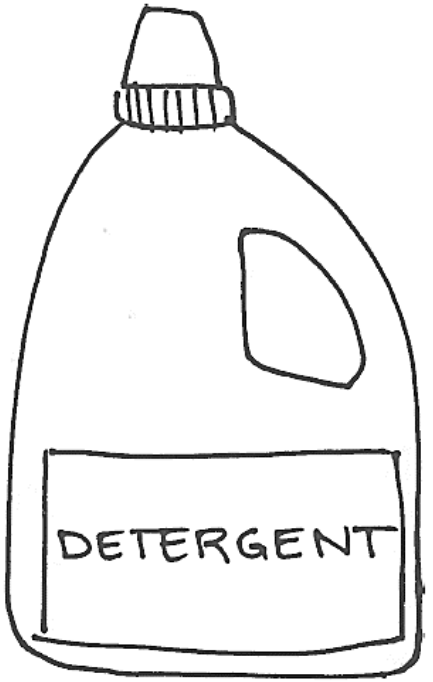
Water hardness

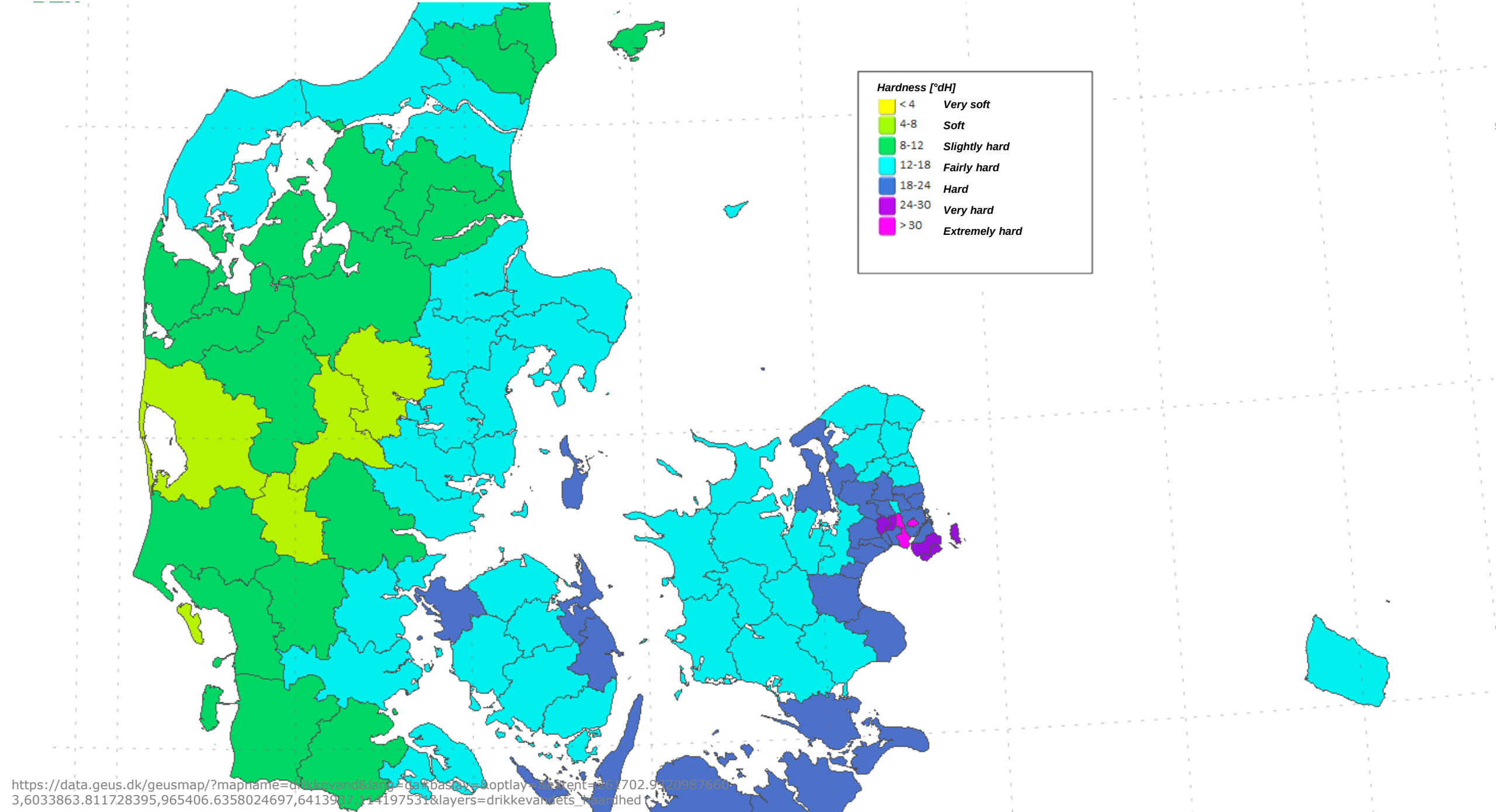








Ca^{2+} Mg^{2+}



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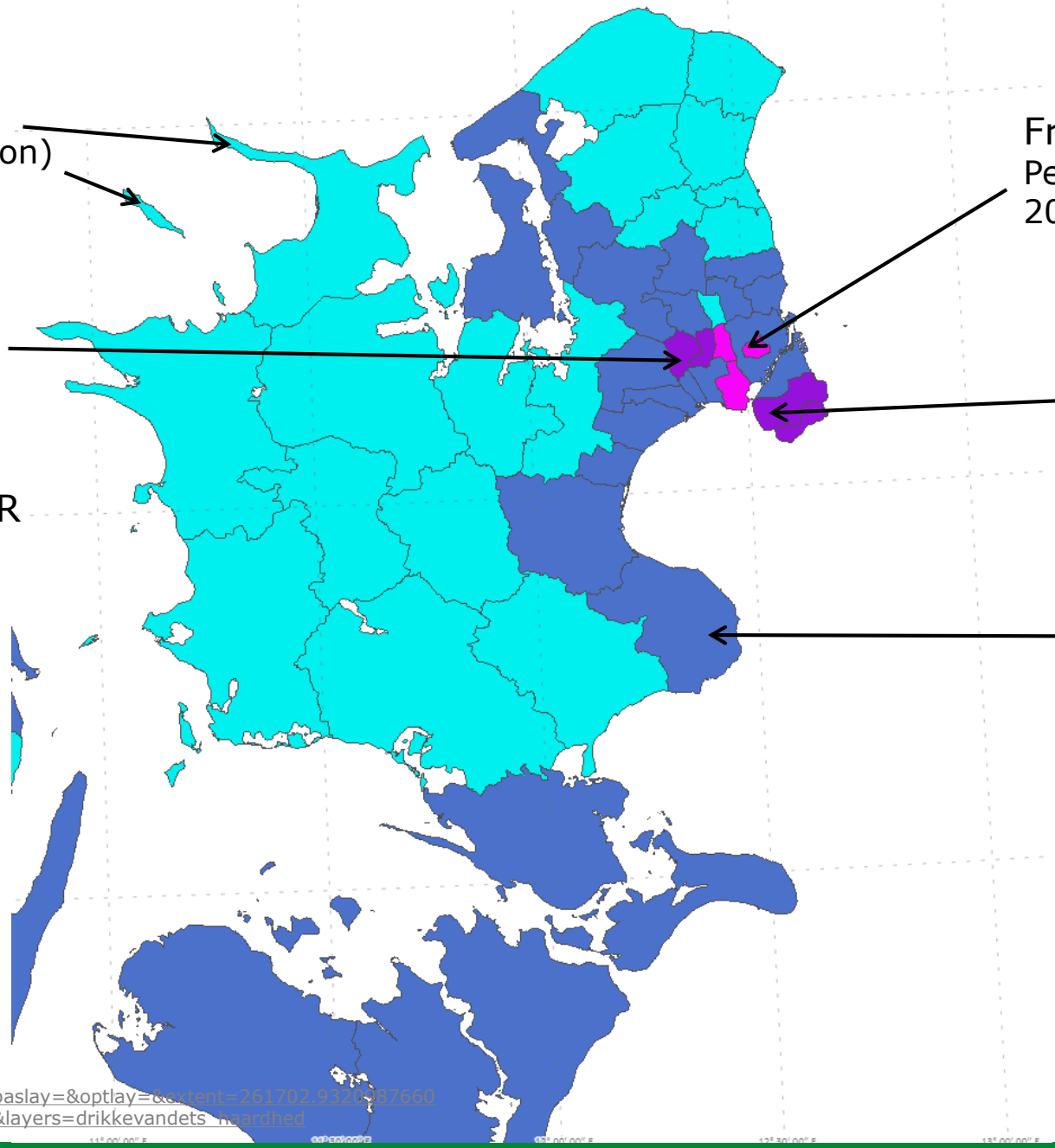
Sejerø and Yderby Lyng
Membrane filtration (desalination)
2017

Brøndbyvester (HOFOR)
Pellet softening
September 2017

Other water works, HOFOR
- 202?



Frederiksberg Forsyning
Pellet softening?
2020-21

Tårnby Forsyning
Ion exchange
September 2017

St. Heddinge
Pellet softening
June 2017

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ERCA2_Decarbo_M-ER-006-FP_1612_web.pdf


https://wwwsapphire-water.ca/projects_category/membrane-systems/.


Carix Austauscher
3
Carix Austauscher

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Espevang water works

Annual production: 900,000 m³

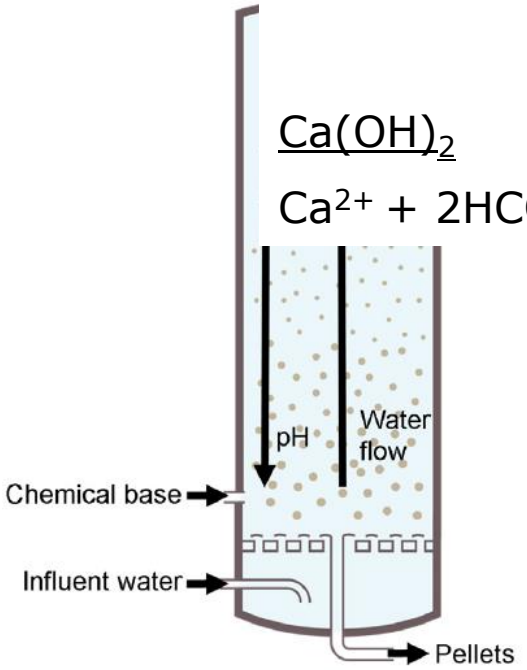
Pellet softening

NaOH

$Ca^{2+} + HCO_3^- + NaOH \rightarrow CaCO_3(s) + Na^+ + H_2O$

$Ca(OH)_2$

$Ca^{2+} + 2HCO_3^- + Ca(OH)_2 \rightarrow 2CaCO_3(s) + 2H_2O$



Tang et al. (2019)

$Ca^{2+} + 2Na^+$-ion exhanger → Ca^{2+}-ion exchanger + $2Na^+$

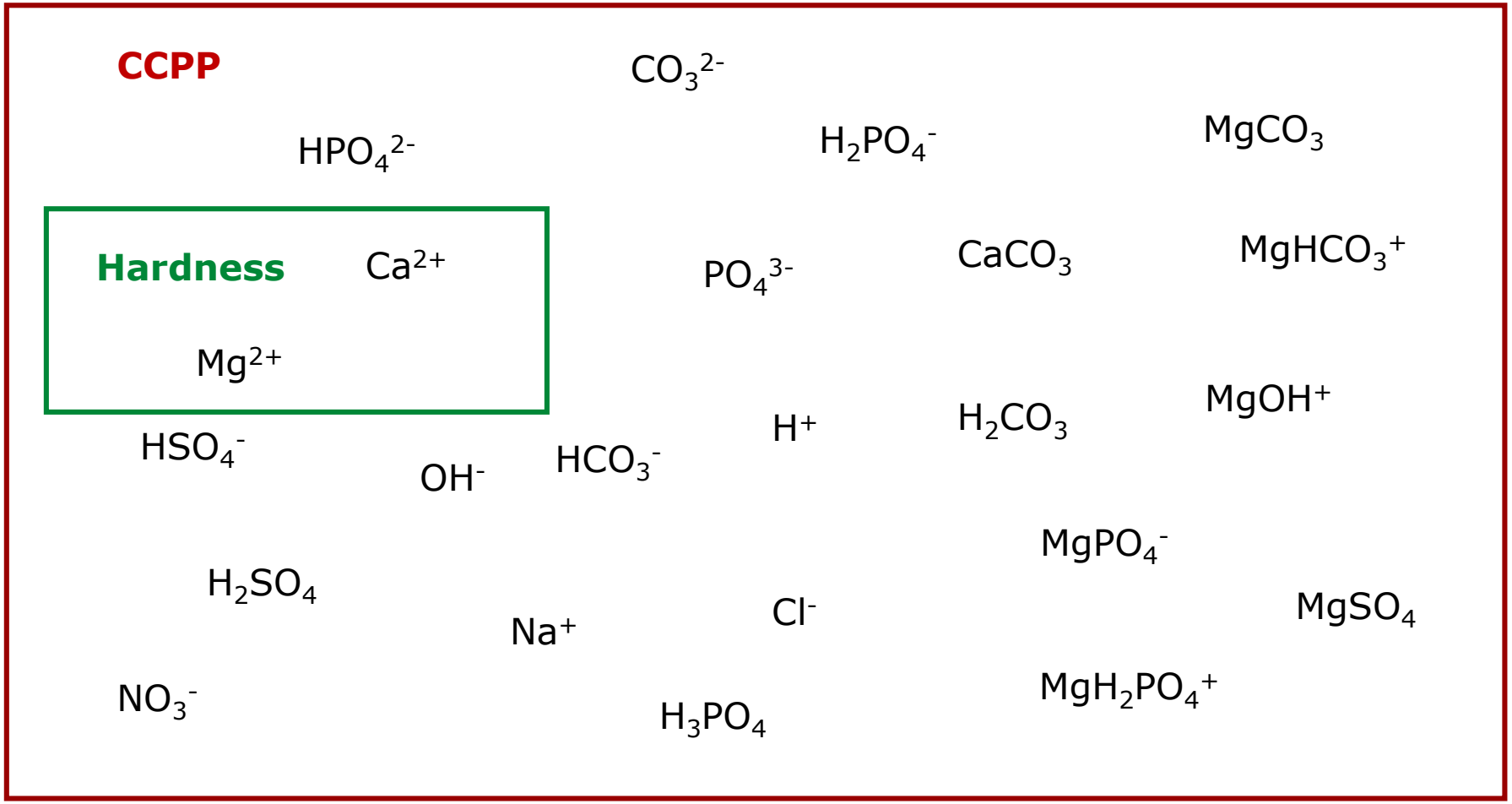
$Mg^{2+} + 2Na^+$-ion exhanger → Mg^{2+}-ion exchanger + $2Na^+$

Ion exchange

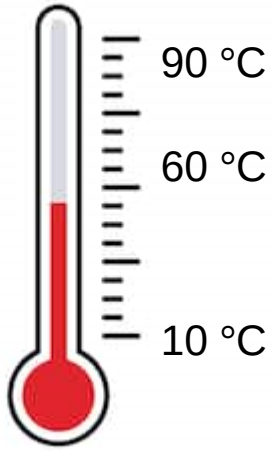
Indicators for technology selection

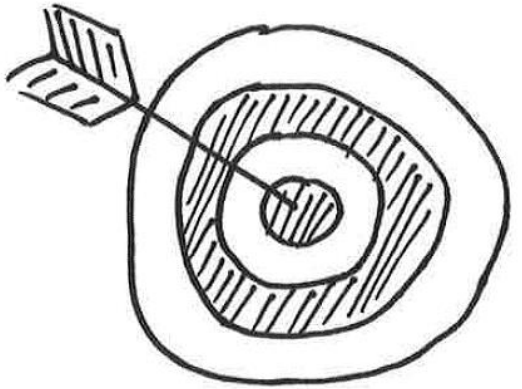
- Costs
- Operating and maintenance requirements
- Water loss
- By-products
- **Water quality**

Calcium Carbonate Precipitation Potential



CCPP depends on temperature





$CCPP_{90} < 0.7$ mmol/L

Godskesen et al. (2019)

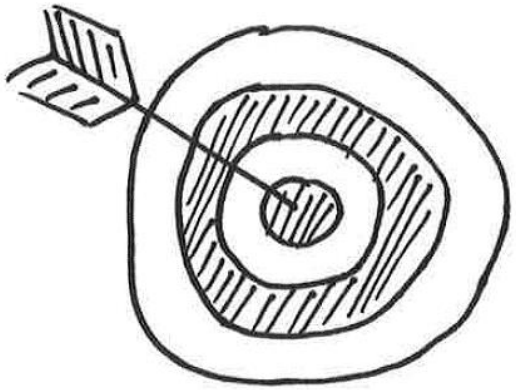
https://www.dynagard.info/3-methods-prevent-pipeline-corrosion/

Corrosion

- Many indicators exist!
- Depends on pipe materials
- Varies from country to country

Galvanized steel

Larson-Skold Index: $\frac{[Cl^-]2[SO_4^{2-}]}{[HCO_3^-]}$



Larson-Skold Index < 1.2

https://www.dynagard.info/3-methods-prevent-pipeline-corrosion

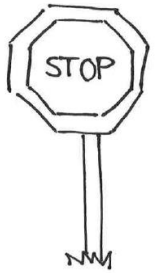
Other indicators

Decayed Missing Filled Surfaces

$$DMF{-}S = \exp\left(1.05 - \frac{0.18(F-0.33)}{0.25} - \frac{0.11(Ca-83.53)}{25.63}\right)$$

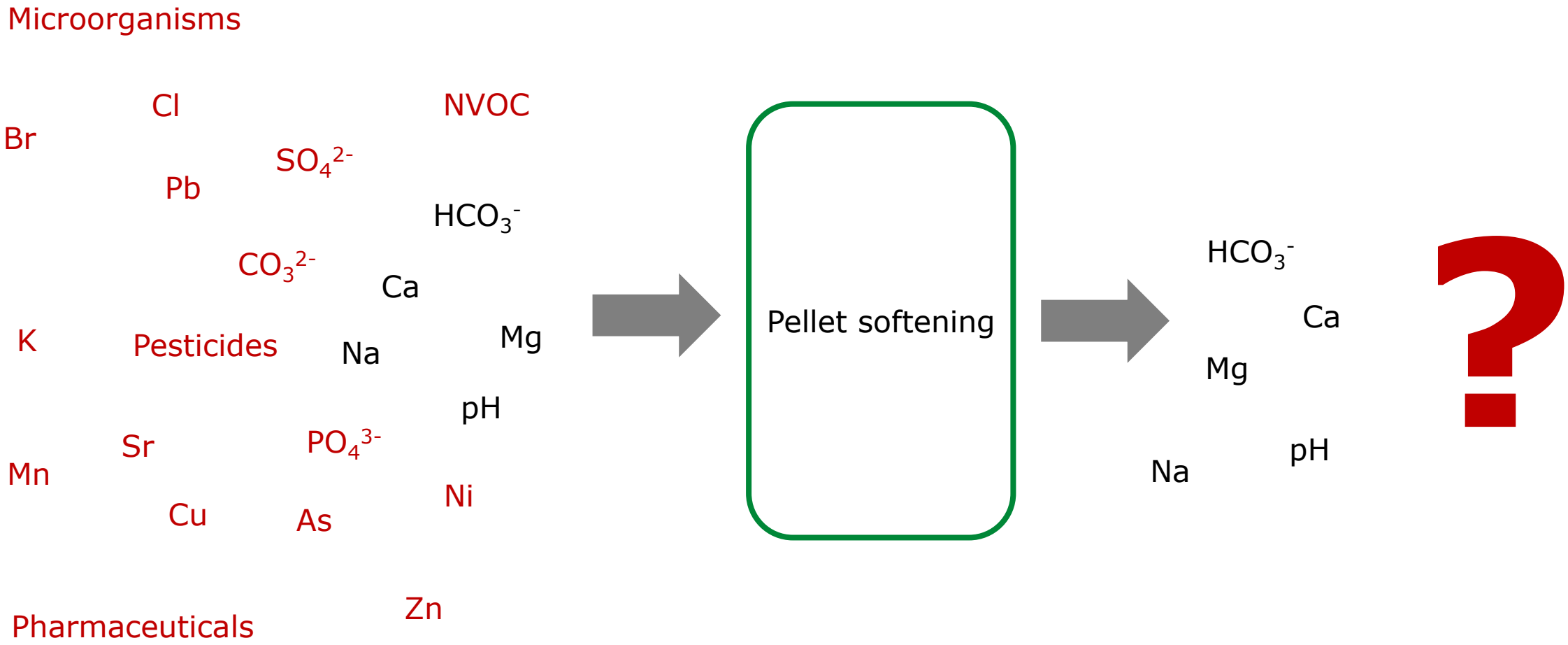
Legislation

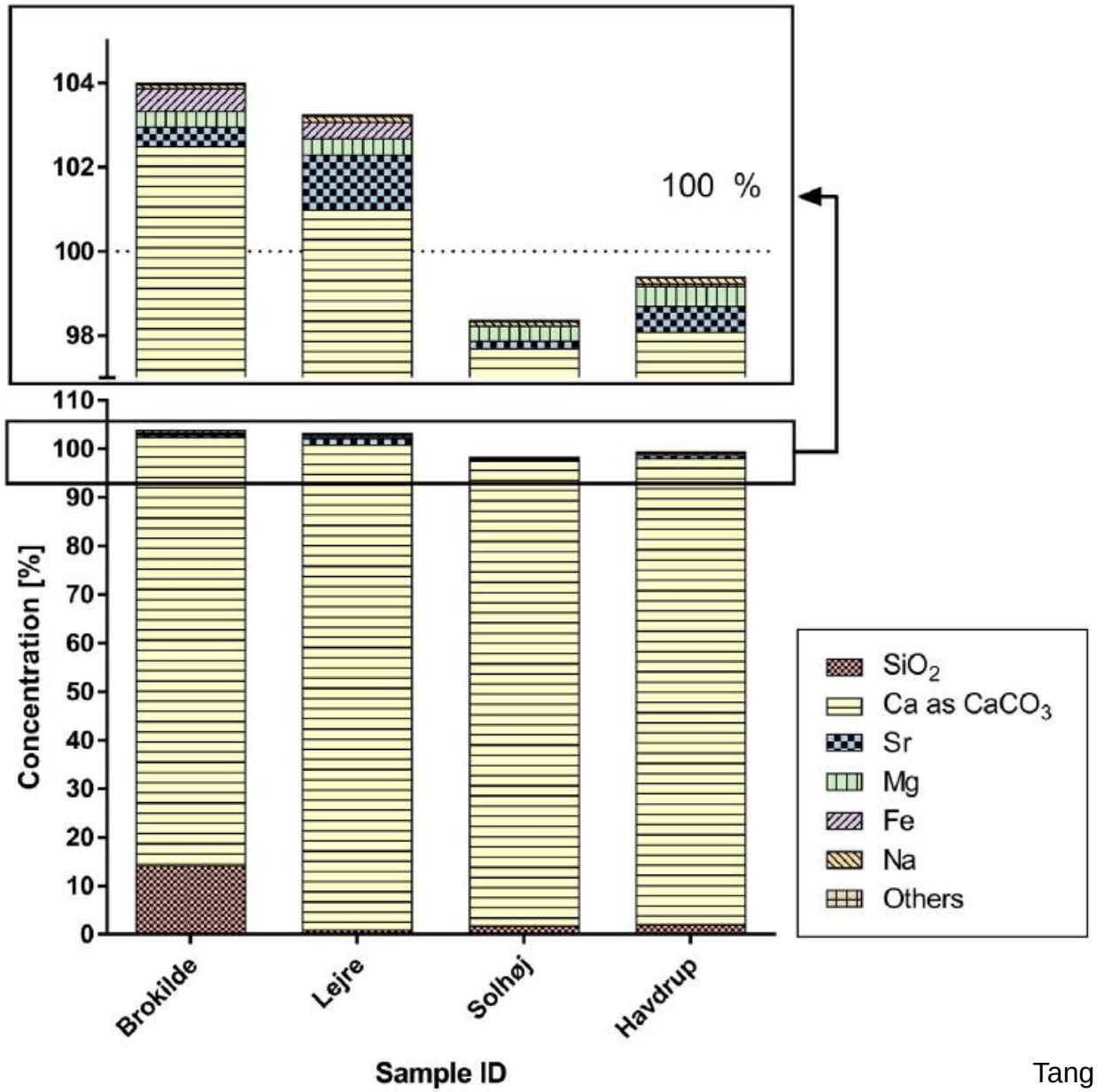
Na < 175 mg/L



Barrier against e.g. heavy metals or organic micropollutants

What happens during softening?





Tang et al. (2019)

Take home messages

- Drinking water softening is being implemented centrally in Denmark, and the utilities must choose between different technologies

- Water quality indicators provide important information about the effects after softening, but requires understanding of the softening processes

- Including indicators beyond hardness reduction and costs can result in a more optimal implementation of drinking water softening

Thank you!

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